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Integrating Energy Storage Devices into Market Management Systems

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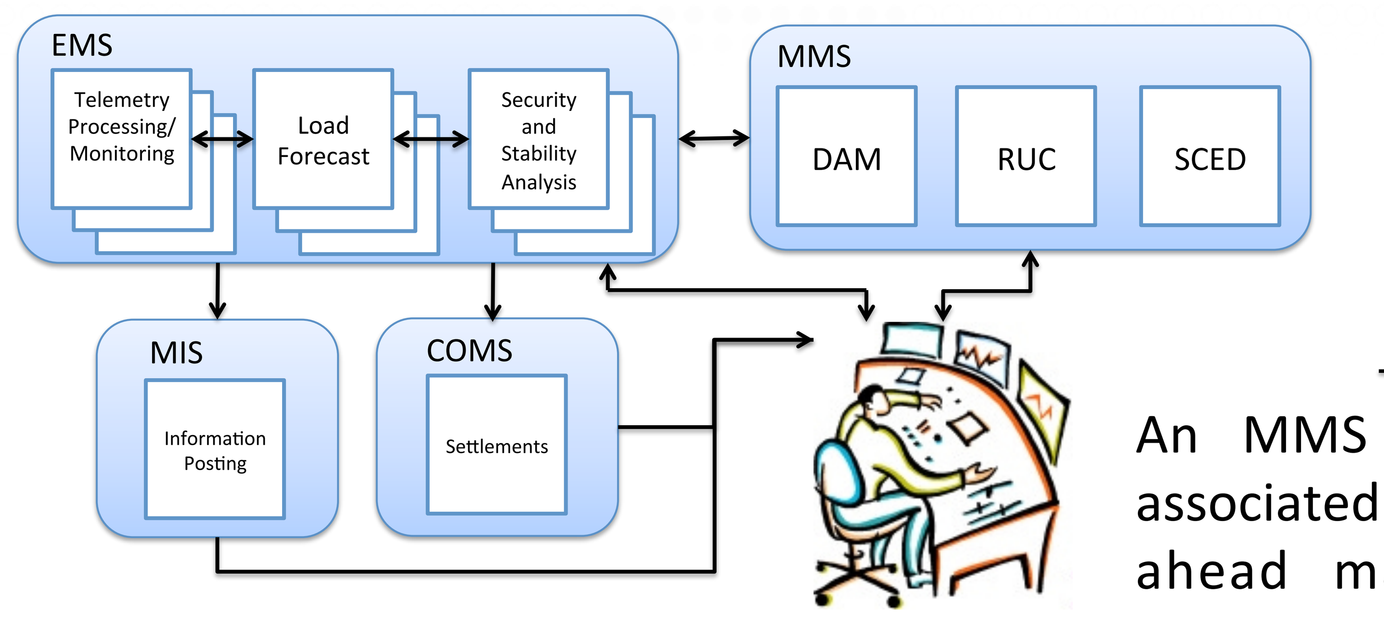
Abstract

Intuitively, the integration of energy storage technologies into vertically integrated utility and ISOs/RTOs-scale systems should confer significant benefits to operations, ranging from mitigation of renewables generation variability to peak shaving. However, the realized benefits of such integration are highly dependent upon the environment in which the integration occurs. In this poster, core issues that arise when integrating storage devices into a Market Management System (MMS) are outlined.



Background

This is the second year of a multi-year effort on developing new markets where energy storage is compensated fairly. Next year we will combine the models introduced here with a new market design developed in year 1 to evaluate its efficiency and impacts.

Market Management Systems

An MMS performs all core resource scheduling functions associated with power systems operations. Examples include day-ahead market (DAM) clearing functions, reliability unit commitment (RUC) processes, security- constrained economic dispatch (SCED), and ancillary service market (ASM) management.

Modeling Energy Storage Devices

The three primary storage processes are illustrated in the figure to the right where energy is shown as flowing left to right. Energy from a generator flows into a storage device through a conversion system:

$$P_{\text{in}} = \eta_{\text{in}} \cdot P_{\text{g}}$$

The efficiency of this conversion system can be mathematically represented by:

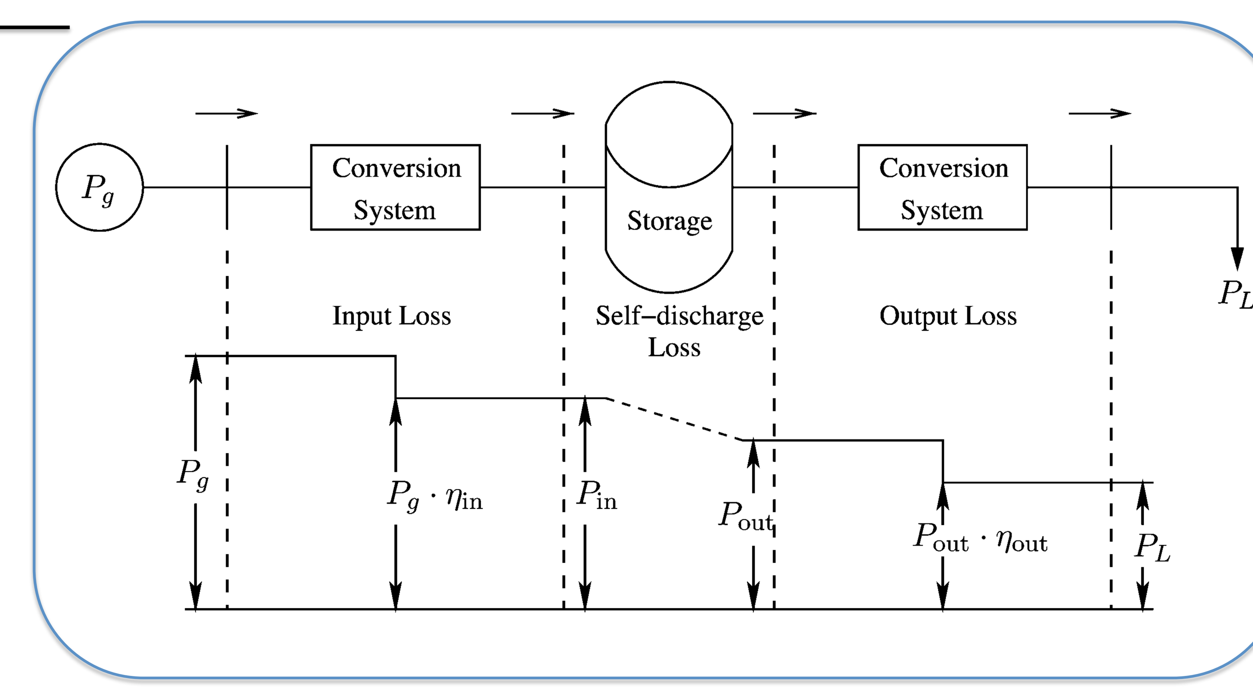
$$SOC(t) = \eta_{sd} \cdot SOC(t-1)$$

The power output of the storage device as a function of the power delivered to the load is:

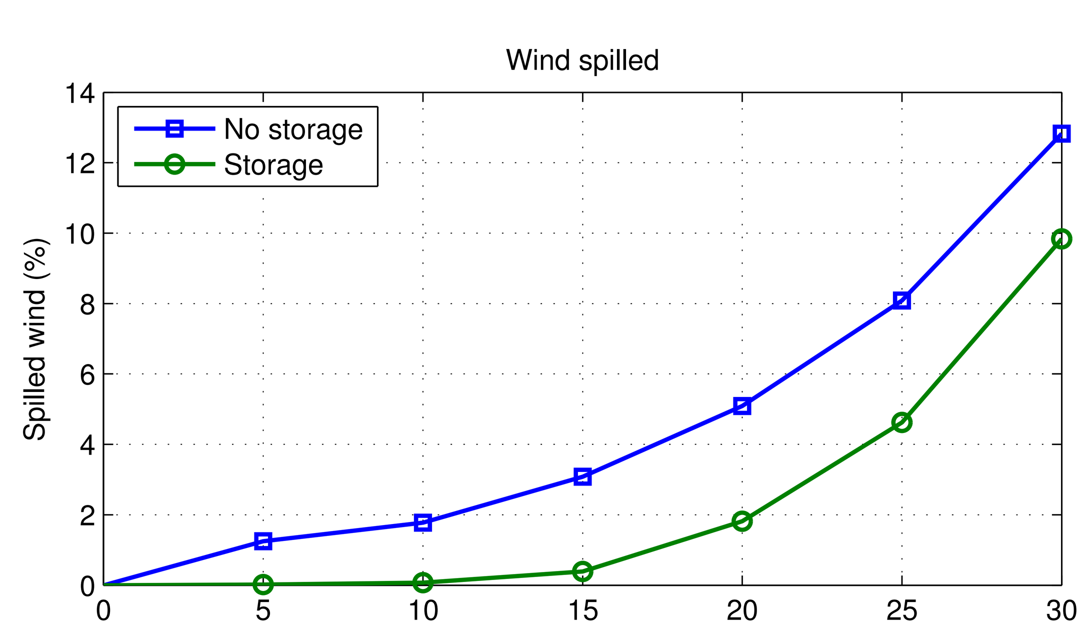
$$P_{\text{out}} = 1/\eta_{\text{out}} \cdot P_{\text{L}}$$

The participation factor of energy storage can be calculated as:

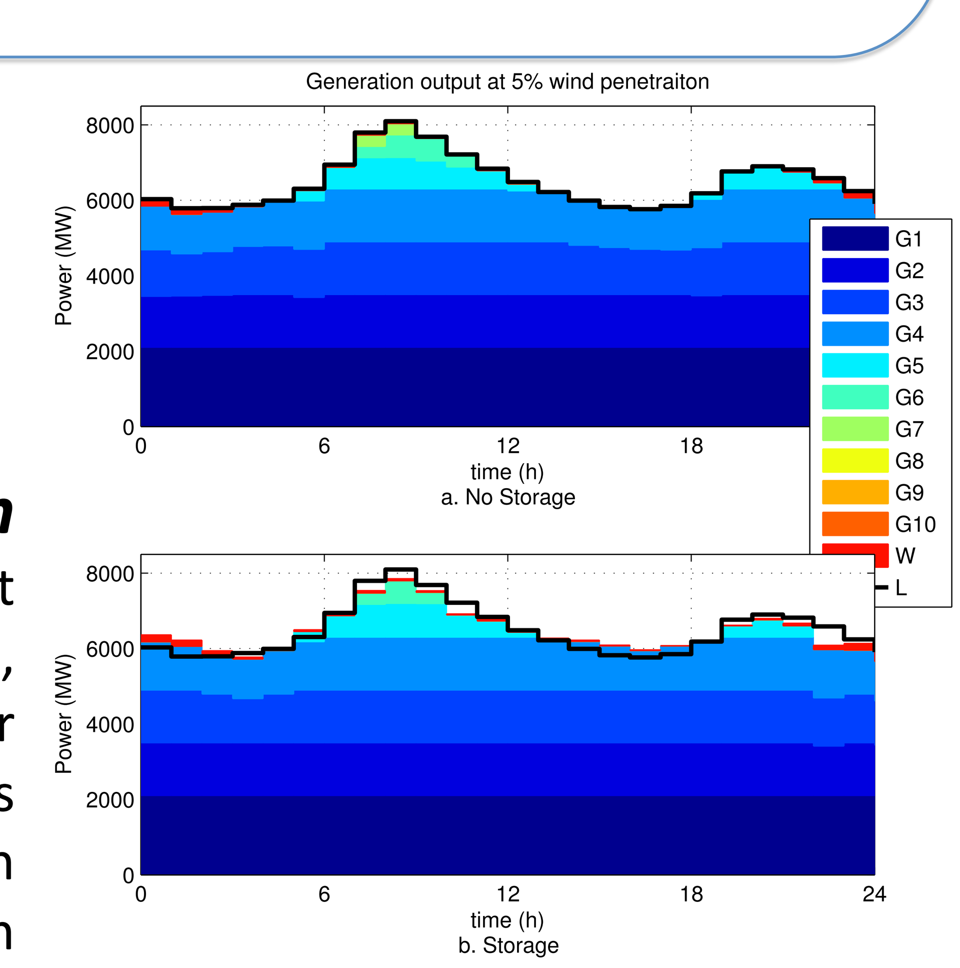
$$\gamma_{s,t} = \frac{\Delta P_{s,t}}{\sum_{j \in G^{\text{Reg}}} \Delta P_{j,t} + \sum_{i \in S^{\text{Reg}}} \Delta P_{i,t}}$$

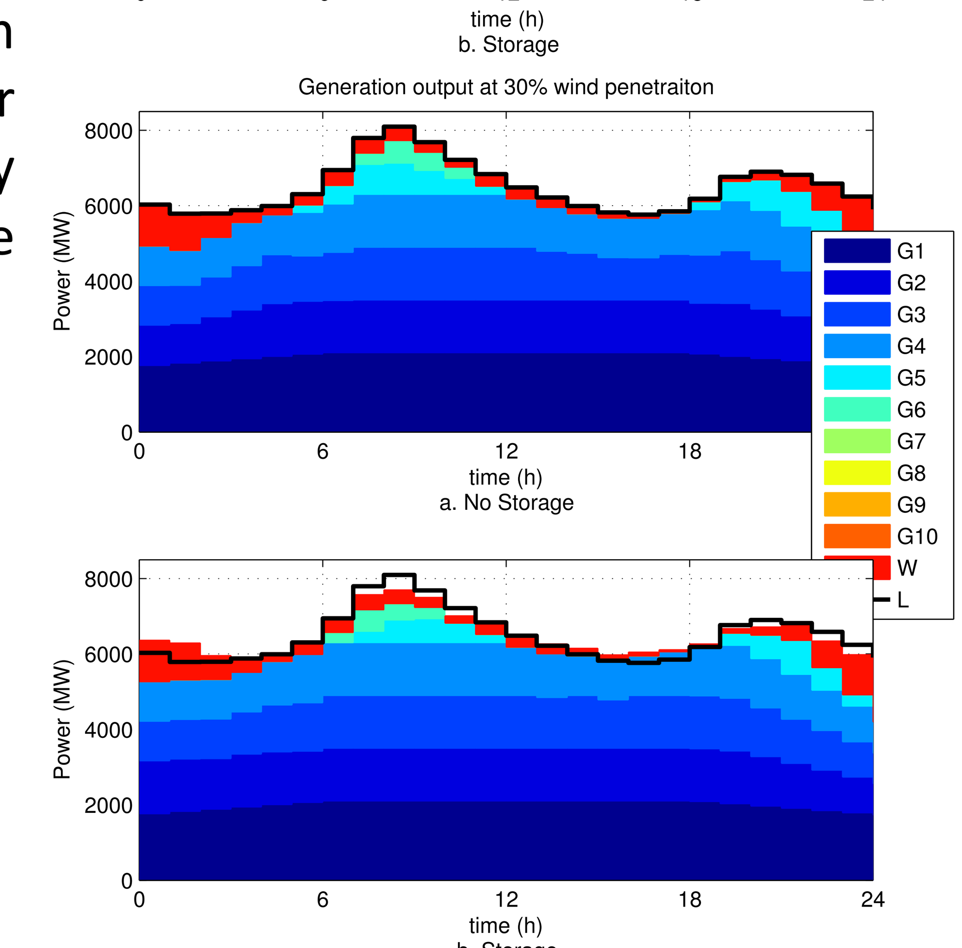


Model Validation



The figures shown here present results from a case study, considering an illustrative power system with ten thermal units representative of the generation mix in the BPA area. The system was operated for a one-year period for several wind energy penetration levels to validate the models presented above.





Opportunities for Market Redesign

Although energy storage devices can be and are integrated into existing ISO/ RTO markets, this does not imply that such integration is maximally beneficially to those market participants, or even maximally beneficial to the market as a whole. FERC Order 755 requires ISOs and RTOs to implement performance-based pay for work done by the different resources that participate in their energy markets and provide ancillary services.

Looking Ahead

The versatility of energy storage devices to function as either a load or a generator is currently an untapped source of flexibility for power systems. Nonetheless, it is that same versatility that makes energy storage integration into current market systems a complex task. We will work on measuring market efficiency given these new models and market structures.

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